CLAIMS:

1. A method comprising:

processing a data stream of information-bearing symbols to form bursts of information symbols;

arranging training symbols within the stream of information-bearing symbols to ensure one polarity transition within three training symbols at a receiver to synchronize timing of a transmitter and the receiver; and

outputting the bursts of information-bearing symbols and training symbols as an ultra wideband (UWB) waveform through a communication channel to the receiver.

2. The method of claim 1, wherein arranging the training symbols further comprises inserting K training symbols within each burst of information-bearing symbols.

3. The method of claim 2, wherein inserting the training symbols comprises inserting the K training symbols as the first K symbols of each burst.

4. The method of claim 1, wherein arranging the training symbols comprises arranging K=4 training symbols according to the following equation where s(k) is the k^{th} symbol of the UWB waveform:

$$s(k)=\begin{cases}+1, & if(k \bmod 4)=0, or, 1 \\ -1, & if(k \bmod 4)=2, or 3\end{cases}.$$

5. A method comprising:

receiving an ultra wideband (UWB) waveform through a wireless communication channel, wherein the received UWB waveform comprises bursts of information-bearing symbols;

selecting a template to be used for estimating the timing offset of a burst of the received UWB waveform, wherein the template comprises a segment of a burst of the received UWB waveform;

correlating the template with a segment of a burst of the received waveform so as to form an estimate of the timing offset of the received UWB waveform; and

outputting a stream of symbol estimates in accordance with the estimated timing offset.

6. The method of claim 5:

wherein selecting the template comprises selecting a segment from a burst of the received UWB waveform of one symbol duration;

wherein the segment of the received UWB waveform to be correlated with the template comprises a segment from a burst of the received UWB waveform of one symbol duration adjacent to the template; and

wherein correlating the template with a segment of the received UWB waveform comprises correlating the template with the selected adjacent segment of one symbol duration from the burst of the received UWB waveform according to the following equation:

$$\hat{R}_{\chi\chi}(n) = \frac{2}{M} \sum_{m=0}^{M/2-1} \left| \int_0^{T_s} \chi_{n,2m}(t) \chi_{n,2m+1}(t) dt \right|$$

wherein $m \in [0, M-1]$ with $M \geq 2$ and $n \in [0, N_f-1]$.

7. The method of claim 6, wherein correlating the template with a segment of the received UWB waveform further comprises selecting the value of $\hat{n}_\varepsilon$ by peak-picking the result of correlating M/2 pairs of adjacent templates and segments of the received UWB waveform according to the following equation:

$$\hat{n}_\varepsilon = \arg\max_n \left\{ \hat{R}_{\chi\chi}(n) \right\}.$$

8. The method of claim 7, wherein n determines the resolution of the estimate of the timing offset.

9. The method of claim 7, wherein n is equal to one of an integer value and a non-integer value.

10. The method of claim 7, wherein n equals one frame duration T_f results in frame-level resolution of the timing offset estimate.

11. The method of claim 5:

wherein the received UWB waveform comprises bursts of information-bearing symbols and training symbols, wherein the training symbols are arranged so as to ensure one polarity transition within three training symbols;

wherein the template to be used for estimating the timing offset of a burst of the received UWB waveform comprises a segment from a burst of the received UWB waveform, wherein the template is selected from the training symbols;

correlating the template with a segment of a burst of the received waveform so as to form an estimate of the timing offset of the received UWB waveform, wherein the segment comprises a segment of one symbol duration from a burst of the received UWB waveform; and

outputting a stream of symbol estimates in accordance with the estimated timing offset.

12. The method of claim 11, wherein the training symbols are the first K symbols of each burst.

13. The method of claim 12, wherein K training symbols within each burst of symbols are arranged so as to ensure at least one polarity transition within one symbol duration of the received UWB signal.

14. The method of claim 13, wherein K=4 training symbols are selected according to the following equation where s(k) is the k^{th} symbol of the transmitted signal:

$$s(k) = \begin{cases} +1, & if(k \bmod 4) = 0, or, 1 \\ -1, & if(k \bmod 4) = 2, or 3 \end{cases}.$$

15. The method of claim 11:

wherein the template comprises a segment of one symbol duration from the K training symbols of a burst of the received UWB waveform;

wherein the segment of the received UWB waveform to be correlated with the template comprises a segment of one symbol duration from the K training symbols of a burst of the received UWB waveform, wherein the segment is adjacent to the template; and

wherein correlating the template with the segment of the received UWB waveform comprises correlating the template with the selected adjacent segment of one symbol duration from the burst of the received UWB waveform according to the following equation:

$$\hat{R}_{\chi\chi}(n) = \frac{2}{M} \sum_{m=0}^{M/2-1} \left| \int_0^{T_s} \chi_{n,2m}(t) \chi_{n,2m+1}(t) dt \right|$$

wherein m $\in$ [0, M-1] with M $\geq$ 2 and n $\in$ [0, N_f-1].

16. The method of claim 12, wherein correlating the template with a segment of the received UWB waveform further comprises selecting the value of $\hat{n}_\varepsilon$ by peak-picking the result of correlating M/2 pairs of adjacent templates and segments of the received UWB waveform according to the following equation:

$$\hat{n}_\varepsilon = \arg\max_n \left\{\hat{R}_{\chi\chi}(n)\right\}.$$

17. The method of claim 15, n determines the resolution of the estimate of the timing offset.

18. The method of claim 15, wherein n is equal to one of an integer value and a non-integer value.

19. The method of claim 15, wherein n equals one frame duration T_f results in frame-level resolution of the timing offset estimate.

20. A wireless communication device comprising:

a pulse generator that processes a data stream of information bearing symbols to form bursts of information bearing symbols and arranges training symbols within the stream of information-bearing symbols to ensure one polarity transition within three training symbols at a receiver to synchronize timing of a transmitter and the receiver; and

a pulse shaping unit that outputs an ultra wideband (UWB) transmission waveform from the bursts of information-bearing symbols and training symbols.

21. The wireless communication device of claim 20, wherein the pulse generator arranges K training symbols within each burst of information-bearing symbols.

22. The wireless communication device of claim 21, wherein the pulse generator arranges the K training symbols as the first K symbols of each burst.

23. The wireless communication device of claim 22, wherein the pulse generator arranges K=4 training symbols according to the following equation where s(k) is the k^{th} symbol of the UWB waveform:

$$s(k)=\begin{cases}+1, & if(k \bmod 4)=0, or, 1\\ -1, & if(k \bmod 4)=2, or 3\end{cases}.$$

24. A wireless communication device comprising:

an antenna to receive an ultra wideband (UWB) waveform through a wireless communication channel, wherein the received UWB waveform includes bursts of information-bearing symbols;

a timing synchronization unit to form an estimation of a timing offset based on the received UWB waveform; and

a symbol detector to output a stream of estimate symbols based on the estimate of the timing offset.

25. The wireless communication device of claim 24, wherein the timing synchronization unit:

selects a template wherein the template comprises a segment of a burst of the received UWB waveform; and

correlates the template with a segment of a burst of the received waveform so as to form an estimate of the timing offset of the received UWB waveform.

26. The wireless communication device of claim 25, wherein the timing synchronization unit:

selects the template wherein the template comprises a segment from a burst of the received UWB waveform of one symbol duration; and

wherein the segment of the received UWB waveform to be correlated with the template comprises a segment from a burst of the received UWB waveform of one symbol duration adjacent to the template; and

correlates the template with a segment of the received UWB waveform comprising a segment from a burst of the received UWB waveform of one symbol duration, the segment being adjacent to the template, to form an estimate of the timing offset according to the following equation:

$$\hat{R}_{\chi\chi}(n) = \frac{2}{M} \sum_{m=0}^{M/2-1} \left| \int_0^{T_s} \chi_{n,2m}(t) \chi_{n,2m+1}(t) dt \right|$$

wherein $m \in [0, M-1]$ with $M \geq 2$ and $n \in [0, N_f-1]$.

27. The wireless communication device of claim 26, wherein the timing synchronization unit forms an estimate of the timing offset by peak-picking the result of correlating the M/2 pairs of adjacent templates and segments of a burst of the received UWB waveform according to the following equation:

$$\hat{n}_\varepsilon = \arg\max_n \left\{ \hat{R}_{\chi\chi}(n) \right\}.$$

28. The wireless communication device of claim 27, wherein n determines the resolution of the estimate of the timing offset.

29. The wireless communication device of claim 27, wherein n is equal to one of an integer value and a non-integer value.

30. The wireless communication device of claim 27, wherein n equals one frame duration T_f results in frame-level resolution of the timing offset estimate.

31. The wireless communication device of claim 24:

wherein the antenna receives a UWB waveform comprising bursts of information-bearing symbols and training symbols;

wherein the timing synchronization unit selects a template, wherein the template comprises a segment of a burst from the training symbols of the received UWB waveform and correlates the template with a segment of a burst from the training symbols of the received waveform so as to form an estimate of the timing offset of the received UWB waveform; and

wherein the symbol detector outputs a stream of estimate symbols based on the estimate of the timing offset.

32. The wireless communication device of claim 31, wherein the antenna receives K training symbols as the first K symbols for each burst.

33. The wireless communication device of claim 31, wherein K training symbols within each burst of symbols are arranged so as to ensure at least one polarity transition within one symbol duration of the received UWB waveform.

34. The wireless communication device of claim 33, wherein K=4 training symbols are arranged according to the following equation where s(k) is the k^{th} symbol of the transmitted signal:

$$s(k)=\begin{cases}+1, & if(k \bmod 4)=0, or, 1\\ -1, & if(k \bmod 4)=2, or 3\end{cases}.$$

35. The wireless communication device of claim 31, wherein the timing synchronization unit:

selects the template, wherein the template comprises a segment of one symbol duration from the K training symbols of a burst of the received UWB waveform;

correlates the template with a segment of the received UWB waveform, wherein the segment comprises the segment of one symbol duration from the K training symbols of the burst of the received UWB waveform adjacent to the template, according to the following equation:

$$\hat{R}_{\chi\chi}(n) = \frac{2}{M} \sum_{m=0}^{M/2-1} \left| \int_0^{T_s} \chi_{n,2m}(t) \chi_{n,2m+1}(t) dt \right|$$

wherein m ∈ [0, M-1] with M ≥ 2 and n ∈ [0, N_f-1].

36. The wireless communication device of claim 35, wherein correlating the template with a segment of the received UWB waveform further comprises selecting the value of $\hat{n}_\varepsilon$ by peak-picking the result of correlating M/2 pairs of adjacent templates and segments of the received UWB waveform according to the following equation:

$$\hat{n}_\varepsilon = \arg\max_n \{\hat{R}_{\chi\chi}(n)\}.$$

37. The wireless communication device of claim 36, wherein n determines the resolution of the estimate of the timing offset.

38. The wireless communication device of claim 36, wherein n is equal to one of an integer value and a non-integer value.

39. The wireless communication device of claim 36, wherein n equals one frame duration T_f results in frame-level resolution of the timing offset estimate.

40. The wireless communication device of claim 24, wherein the symbol detector outputs a stream of estimate symbols based on the timing offset by delaying a time to initiate the estimate of the received signal are initiated by $\hat{n}_{\varepsilon}T_f$ seconds.

41. A system comprising:

a transmitter that processes a data stream of symbols to form bursts of information-bearing symbols and generates an ultra wideband (UWB) waveform through a wireless communication channel; and

a receiver that receives the transmitted signal through a wireless communication channel, selects a segment of the received UWB waveform to use as a template, forms an estimate of the timing offset based on the correlation of the template with the received UWB waveform, and outputs a stream of estimate symbols based on the estimate of the timing offset.